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AUDITORY VERBAL EXPERIENCE AND AGENCY IN WAKING, SLEEP ONSET, REM, AND NON-REM SLEEP

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Abstract

We present one of the first quantitative studies on auditory verbal experiences ("hearing voices") and auditory verbal agency (inner speech, and specifically "talking to (imaginary) voices or characters") in healthy participants across states of consciousness. Tools of quantitative linguistic analysis were used to measure participants' implicit knowledge of auditory verbal experiences (VE) and auditory verbal agencies (VA), displayed in mentation reports from four different states. Analysis was conducted on a total of 569 mentation reports from rapid eye movement (REM) sleep, non-REM sleep, sleep onset, and waking. Physiology was controlled with the nightcap sleep–wake mentation monitoring system. Sleep-onset hallucinations, traditionally at the focus of scientific attention on auditory verbal hallucinations, showed the lowest degree of VE and VA, whereas REM sleep showed the highest degrees. Degrees of different linguistic-pragmatic aspects of VE and VA likewise depend on the physiological states. The quantity and pragmatics of VE and VA are a function of the physiologically distinct state of consciousness in which they are conceived.

1 Introduction

We present one of the very first quantitative studies of auditory verbal experiences (VE) and auditory verbal agencies (VA) in healthy participants across physiology-monitored states of consciousness. VE describe the perception of (imaginary) voices in the absence of adequate external stimuli. VA describe inner speech as verbalized thought, which can involve talking to oneself, or to defined or undefined imaginary voices or characters.

VE and VA, as expressed in mentation reports, can potentially be markers of auditory verbal hallucinations (AVHs), which have been proposed to be on the same continuum as inner speech (Harley, 1986, 2014; McGuire et al., 1996). The analysis of VE and VA may help the ongoing search for a cut-off point between healthy and clinical AVHs (Bick & Kinsbourne, 1987; Cho & Wu, 2013, 2014; Fernyhough, 2004; Jones & Fernyhough, 2007a,b; McGuire et al., 1995; Moseley & Wilkinson, 2014; Seal, Aleman, & McGuire,

2004). While it has recently been argued that as much as 10%–15% of the general population experience AVHs (Sommer et al., 2010), it is still being debated if AVHs in those individuals assessed as healthy differ in form and function from AVHs as they occur, for example, in connection with schizophrenia, or if they are to be placed on a continuum model of psychosis (Allardyce, Gaebel, Zielasek, & van Os, 2007; Badcock & Hugdahl, 2012; Daalman et al., 2011; Van Os, Linscott, Myin-Germeys, Delespaul, & Krabbendam, 2009). Much clinical research is devoted to the connection between AVHs and neuropsychiatric disorders such as schizophrenia (Ditman & Kuperberg, 2005; Larøi et al., 2012; Poulet et al., 2005; Vercammen et al., 2009). The current work seeks to contribute to this discussion (a) by presenting a linguistic tool devised to quantify VE and VA as indexed in the natural speech of mentation reports, and (b) by determining the healthy baselines of VE and VA across states of consciousness with a tool that can subsequently be used for clinical populations.

The current research was inspired by the observation that brain areas associated with AVHs in patients with schizophrenia overlap with areas that have been shown to be hyperactivated in healthy rapid eye movement (REM) sleep: Mapping studies on patients with schizophrenia identify activity in the anterior cingulate cortex (ACC) as a neuronal correlate of AVHs, specifically Brodmann areas 24 and 32 (Lennox, Bert, Park, Jones, & Morris, 1999; Shergill, Brammer, Williams, Murray, & McGuire, 2000; Silbersweig et al., 1995). Jones and Fernyhough (2007b) note that the activation of the right anterior cingulate gyrus is a potential factor of AVHs. Further, the ACC shows higher metabolic activity in REM sleep than in all other sleep stages (Buchsbaum, Hazlett, Wu, & Bunney, 2001). The ACC has strong neuronal connections with the dorsolateral prefrontal cortex (DLPFC; Barbas, Ghashghaei, & Dombrowski, 1999). Contrary to the ACC, the DLPFC is hypoactive in REM—with all its known effects on cognition and cognitive control in REM dreaming (Hobson, 2009). An updated version of the activation-synthesis hypothesis on the neurobiology of dreaming addresses the ACC hyperactivation and DLPFC hypoactivation in REM sleep and attributes the occurrence of dream movement and emotion especially to ACC hyperactivation (Muzur, Pace-Schott, & Hobson, 2002). However, a correlation of ACC activation and VE and VA in REM sleep has yet to be proposed.

So far, research on VE in healthy participants has mainly focused on partial wakefulness. Mavromatis (1988) notes from his research experience that AVHs in sleep onset can be of different pragmatic qualities, taking the form of neologisms, irrelevant and nonsense utterances, references to previously experienced spoken conversation, and statements to oneself, as well as the impression that one's name is being called. Jones, Fernyhough, and Larøi (2010) conducted a questionnaire-based study on AVHs in sleep onset with the goal of establishing a number of their phenomenological properties. Lewis-Hanna, Hunter, Farrow, Wilkinson, and Woodruff (2011) demonstrate that healthy individuals prone to auditory hallucinations during sleep onset exhibit increased cortical responses to external auditory stimuli in waking.

Zadra, Nielsen, and Donderi (1998) propose that VE are reported in approximately 53% of all reports of nightly dreams, as conceived in home settings and without electroencephalographic measurements of the specific sleep phases. These findings roughly fit those of McCarley and Hoffmann (1981), who reported that auditory experiences occur in about 60% of all dreams.

This study proposes that VE and VA in healthy humans are functions of spontaneous brain activity, occurring normally and regularly over the human circadian cycle. They form an integral part of human consciousness along with simulations of other modalities, such as visual, haptic, olfactory, and auditory non-verbal hallucinations. It remains to be seen if such regular VE and VA can be quantitatively, pragmatically, and functionally distinguished from AVHs as clinical symptoms. VA and VE are investigated across several states of consciousness. A linguistic tool was devised to quantify grammatical references to VE and VA in a database of mentation reports.

Independent, blind native speaker judges were asked to rate reports from physiology-monitored states of consciousness and to classify the identified instances of VE and VA with regard to their linguistic-pragmatic features. The classification of pragmatic features of VE and VA is partly based on the classification of AVHs devised by Jones et al. (2010), to promote comparability between their explicit (questionnaire) measurements and the current implicit method of quantitative linguistic report analysis.

This study reports on VE and VA in physiology-monitored states of waking, sleep onset, REM sleep, and non-REM sleep. It is hypothesized that day-to-day VE and VA in healthy participants differ between physiological states in their quantity as well as in their linguistic-pragmatic quality: As similar regions within the ACC are as hyperactive during AVHs in patients with schizophrenia as they are in REM sleep, we hypothesize that REM sleep exhibits the highest quantity of VE and VA. REM sleep is thus expected to exhibit even more VE and VA than sleep onset, the state that is traditionally at the focus of research on AVHs. As REM sleep shows a unique pattern of local hypo- and hyperactivation (a re-activated ACC while the closely linked DLPFC remains silent), we predict changes in the quality of VE and VA between states.

2 Method

Quantitative linguistic analyses were conducted of participants' mentation reports from different states of consciousness. This objective third-person method is expected to measure mental events as they become expressed in the natural language of the first-person report (for further explanation see Speth, Frenzel, & Voss, 2013; Speth, Speth, & Harley, 2015; Speth & Speth, 2016; Speth et al., in press). This study investigates if reports on physiologically distinct states of consciousness (waking, sleep onset, non-REM sleep, and REM sleep) differ in their numbers of linguistic constructs that indicate VE and VA. Four independent native speaker raters (2 female, 2 male) were instructed to analyze a database of participants' reports on mental activity across sleep and wake states. The report raters were blind in so far as they were not informed after which state of consciousness the individual reports had been conceived.

2.1 Database description

The report database consisted of a total of 563 reports from 16 healthy undergraduate students (19–26 years of age, 8 male, 8 female). Participants had provided informed consent and were paid for their participation in the study. After participants had completed a preliminary training protocol, they delivered dictated mentation reports from the waking state, sleep onset, non-REM sleep, and REM sleep on a minimum of 14 days.

Daytime mentation reports were obtained via pager notifications at four random times a day, within a time frame in which participants had stated they would be available. For daytime mentation reporting, participants were given the following standardized report-eliciting questions: "When you are beeped, think back and try to remember what was going on in your mind the time prior to your being beeped (i.e., anywhere up to fifteen minutes before the beep). Where were you? Who else was there? What were you doing? What were you seeing, thinking, and feeling? What was happening around you?" The method of using offline reports from waking by asking participants to report on their mental events has been used in previous studies to maximize comparability between dream and waking reports (Ajilore, Stickgold, Rittenhouse, & Hobson, 1995; Cantero, Atienza, Stickgold, & Hobson, 2002; Fosse, Stickgold, & Hobson, 2001; Stickgold, Pace-Schott, & Hobson, 1994).

Nocturnal reports were collected using a home-based sleep monitoring system, the Nightcap, which has been shown to reliably distinguish REM from non-REM sleep by monitoring head movements and eyelid movements (Ajilore et al., 1995; Fosse et al., 2001; Stickgold, Malia, Fosse, Propper, & Hobson, 2001; Yun, Obermeyer, & Benca, 1997). Instrumental awakenings were performed by means of a noise signal. For nocturnal mentation reporting, participants were given the following standardized report-eliciting questions: "When you awaken, think back and try to remember what was going on in your mind in the time prior to waking. Where did you think you were? Who else was there (i.e., in your dream)? What were you doing? What were you seeing, thinking, and feeling? What was happening around you?"

All reports were collected via a dictation device and later transcribed and edited according to the technique of Antrobus (1983) by removing extraneous utterances (um, er, ah), rephrasings ("I was in my bedroom, in my bedroom at home"), and commentary ("I had actually had lunch with him yesterday, and we had talked about the same subject").

2.2 Quantitative linguistic analysis of mentation reports

Specific linguistic references to VE and VA were quantified in the participants' mentation reports. The linguistic tools used for the quantification are based on linguistic theta

theory (Gruber, 2001; Reinhart, 2002; Reinhart & Siloni, 2005), and in a different version have been used to successfully link degrees of linguistic references to simulated motor activity in mentation reports with motor cortical activation of the respective state of consciousness (Speth et al., 2013,). The tool of *auditory verbal agency analysis* was used to measure (a) inner speech (as initiated directly by the participants or indirectly by the virtual characters in their imagination). The tool of *auditory verbal experience analysis* was used to measure (b) the experience of (simulated) linguistic events by the participants, of perceiving voices in the absence of external acoustic stimuli. As argued previously, this method of quantitative linguistic analysis allows for relatively high qualitative and quantitative accuracy, high research objectivity, applicability, and efficiency (Speth et al., 2013, , 2016; Speth & Speth, 2016).

2.2.1 Auditory verbal agency analysis

In linguistic theta system theory, the initiator of an event takes on a specific thematic (theta) role within a sentence or phrase (Gruber, 2001; Reinhart, 2002; Reinhart & Siloni, 2005). He or she is the *agent* who performs an action. In the phrase "Mimi throws a ball," *Mimi* is the agent. The agent is defined through his or her relationship to the predicate of a phrase: He or she is *performing* the action described by the predicate. Mimi is the one who is *doing something*. The agent is described by a noun phrase, but the agent does not necessarily correlate with the grammatical subject. Consider the following phrases, where Mimi is the agent in both (i) and (ii), but the syntactic subject only in the active version (i).

1. Mimi opens the box.
2. The box is opened by Mimi.

This study focuses on a special variety of agency: *verbal agency*. Verbal agency is defined as such agency that is related to speech acts. The verbal agent is the one who is *doing the talking*. The following phrases contain instances of (simulated) verbal agency as they occur in mentation reports:

1. Talking to my teacher about wanting to live on campus.
2. And he was like, yeah, let's go grab something to eat.

3. And we were chatting about love, and the word love, and when you're allowed to use it.

Each of the phrases (i), (ii), and (iii) contains instances of verbal agency.

2.2.2 Auditory verbal experience analysis

In addition to verbal agency, we examined *verbal experience*. In linguistic theta system theory, the *experiencer of an event, state, or action* takes on a specific thematic (theta) role within a sentence or phrase (Gruber, 2001; Reinhart, 2002; Reinhart & Siloni, 2005). The *experiencer* is the entity which receives sensory, cognitive, or emotional input from the event, state, or action described by the predicate, without acting or controlling that event, state, or action. In the phrase "Mimi feels sick," *Mimi* is the experiencer. The experiencer is defined through his or her relationship to the state (described by the predicate). *Mimi,* however, does not control the one who is *doing something*. The experiencer is described by a noun phrase. Consider the following phrases:

1. Mimi sees a ghost.
2. The ghost is seen by Mimi.

Mimi is the experiencer in both (i) and (ii). This study focuses on a special variety of experience: *auditory verbal experience*, as experienced by the participant and reported from the first-person point of view. *Auditory verbal experience* is defined as such instances of theta theory experience that are related to language events, states, or actions. The auditory verbal experiencer is the one who is *hearing language*. He or she receives acoustic sensory input from the event, state, or action described by the predicate in a phrase. In the context of mentation reports, these linguistic events cannot be attributed to an external stimulus, and therefore have a hallucinatory quality. The following phrases contain instances of verbal experience as they occur in the mentation reports:

1. My girlfriend telling me that she had, had actually cheated on me twice last year and this is with one guy especially who I find really annoying […]
2. Once again I was speaking to God. He was going to; I have a keen sort of impression that he's like speaking to me.

3. I was just having a dream about … we were listening to a symphony and one of the people who was listening to the symphony agreed that the symphony would be … listening to … that therefore he was very paranoid and like wanted the symphony to be very, really loud.

Each of the phrases (i), (ii), and (iii) contain instances of verbal agency. Examples (i) and (ii) each contain one instance of verbal agency and one instance of verbal experience. Example (iii) contains one instance of verbal experience that is experienced from the first-person (plural) point of view, and one instance of verbal experience that is experienced from the third-person (singular) point of view.

2.3 Report rating instructions

All raters were asked to judge all reports. Raters were given a hard copy of the reports and an instruction manual in which they were asked to identify instances of (simulated) verbal agency as well as verbal experience in the reports. The instruction manual contained the brief definitions of auditory verbal agency and auditory verbal experience that are given above. Raters were issued with an Excel rating table, in which they were asked to use one line for each VA instance, and one for each VE instance, always noting the number of the report in which they find that VA or VE instance in the "report" column. The rating table contained different columns in which raters were asked to further classify instances of VA and VE according to the definitions given in the instruction manual. This classification is partly based on the one devised by Jones et al. (2010) for AVHs in sleep onset, but it incorporates linguistic information on grammatical points of view as well as additional pragmatic information on the speech acts. Raters were asked to identify the verbal agent as the experimental subject reporting from the first-person point of view, or as imaginative agents reporting from the second- or third-person points of view. The respective (simulated) speech act connected to each agency or experiencer instance was classified as command/suggestion/advice, a question, as unspecified communication ("they were having a conversation"; "we were talking about things"), or other. Raters were also asked to judge the speech act adequacy in the imaginative context, as well as its pragmatics ("linguistically and acoustically comprehensible"; "psychological neologism"; "acoustically incomprehensible ["he said something I couldn't really hear"]). The speech act manner was judged by the raters as "nice," "nasty," "dominant," "scary,"

or “neutral.” Raters were also asked to determine the recipient, the theta role experiencer, of the speech act (“reporting subject/group including reporting subject,” “other imaginative characters excluding the reporting subject,” “unspecified/unclear”) and to note if the experiencer utters a reply. The manual further contained the instructions that repetitions be counted separately. For the phrase “we talked and talked and talked,” for example, raters should note three instances of verbal agency. Raters were informed that reports of subjective experience are often transcribed in a way that the original, natural speech is preserved. They would therefore encounter elliptical or grammatically ill-formed sentences, and there would be cases where they would be unsure about their rating decisions. Raters were asked to use their best judgment and decide how to deal with such particular phrases, as not all possible instances of verbal agency and experience possible in natural speech can be predefined.

2.4 Statistical analyses

Identified instances of VA or VE were aggregated for every report, separately for every rater. One-way analyses of variance (anovas) were conducted to test for differences in the number of instances of VA and the number of instances of VE per report between the four states of waking, sleep onset, non-REM, and REM. For post hoc analyses, Games–Howell tests were conducted.

A multivariate analysis of covariance (mancova) was conducted to analyze changes in the number of pragmatic characteristics of VA or VE across states. Pragmatic characteristics were assessed as follows: verbal agency/experience identification (disembodied voices, reporting subject, non-human character, specified person, unspecified person), verbal agency/experience perspective (first person singular, first person plural, third person singular, third person plural), speech act (command/suggestion/advice, unspecified, other), speech act adequacy (adequate, possibly random), speech act quality (linguistically/acoustically comprehensible, psychological neologism, incomprehensible), speech act manner (nice, nasty, dominant, scary, neutral), experiencer/speech act agent (reporting subject, other imaginative character, unspecified/unclear), and experiencer reply (subject replies, subject does not reply, other character replies). To analyze changes in the specific pattern of VA or VE and to clear these results from the overall effect that the number of VA or VE changes between

states, the number of VA or VE per report served as a covariate. Post hoc, multiple analyses of covariance (ancova) and Fisher's least significant difference (LSD) tests were used.

3 Results

Reports from different states of consciousness were distributed as follows: A total of 164 reports stemmed from waking, 150 from sleep onset, 115 from non-REM, and 134 from REM. On average, the four raters identified 136 instances of VA and 249.75 instances of VE in the 563 reports. Linguistic samples from reports collected from the different physiological states can be seen in Table 1.

Table 1: Linguistic samples from reports conceived from waking, sleep onset, REM and non-REM sleep. Verbal agencies and experiences along with the grammatical perspective (first, second, third) from which they are reported are given, as well as the pragmatics.

	sample	**Verbal agency/experience**
Waking	singing that song in my head "…times are good or bad," I don't know I can't remember the lyrics but I hate the song and it's stuck in my head as I was also kind of saying to myself "Mavisto" which is the brand name of the jacket I have	2 x verbal agency experienced by the first person singular, i. e. from the participant's perspective also acting as verbal agent. Speech acts unspecified, speech act adequacies "possibly random", speech act manners "neutral ".
Sleep Onset	Ah, same little God theme again. I was kind of hearing him speak to me or you know, making something up; I mean you can just have that, but I was just hearing "My child, my child." It was kind of comforting.	2 x verbal experience, experienced by the first person singular, with third person agent "disembodied voice". Speech acts "other", speech act adequacies "adequate", speech act manners "nice".
	I was… there was a song going through my head that I'd been listening to earlier tonight by the Grateful Dead and I was just sort of you know mentally singing it.	1 x verbal agency, initiated by the first person singular. Speech act "other", speech act adequacy "random", speech act manner "neutral".
		1 x verbal agency, initiated by the first person singular. Speech act

	I was just thinking. Drip a dolly from the dock… about a little girl hanging over a dock dipping her dolly in trying to catch a fish […] and I kept repeating the drip a dolly from the dock. The sentence went over in my head. I had this image of a dog in my head. A dog with a bell around its neck that was ringing.	"other", speech act adequacy "random", speech act manner "neutral". N/A
non-REM	people speaking in some sort of weird, stilted language, like something out of a movie	1 x verbal agency, initiated by the third person plural, i. e. imaginative characters. Speech act "unspecified communication", speech act manner "neutral".
	there is a woman saying eye glasses, eye glasses with a case, were for girls and she called the case a crocker	1 x verbal agency, initiated by the third person singular. Speech act "command/suggestion/advice", speech act manner "neutral".
	I was talking to my friend, Dave, don't really know what we were talking about actually. But we were talking	1 x verbal agency, initiated by the first person singular, with third person singular as experiencer, speech act manner "neutral". 1 x verbal agency, initiated by the first person plural, i. e. participant and imaginative (non-present) character; speech act "unspecified communication", speech act manner "neutral").
	I was having a conversation with someone. The last thing I remember them saying was something like "Give it up. Let it go."	1 x verbal agency, initiated by the first person singular, speech act "unspecified communication", speech act manner "neutral. 1 x verbal agency, initiated by the third person plural, with participant as experiencer; speech act "command/suggestion/advice", speech act manner "neutral".
REM	Uncle and Erin greeted me as "Senator." "Hi, Senator, hi, Senator" and I was like okay whatever.	1 x verbal agency, initiated by the third person plural, with the first person as experiencer; speech act "other", speech act adequacy "possibly random", speech act manner "nice".
	one of singers; one of the parts, he said "Well my part is very; is wonderful" or something. And I said something to the effect of "Is it subtle or is it	1 x verbal agency, initiated by the third person singular; speech act "other", speech act manner

	something?" He said "What do you mean?" And I said "I don't know."	"neutral". 1 x verbal agency, initiated by the first person singular, with the third person singular as experiencer; speech act "question", speech act adequacy "possibly random", speech act manner "neutral". 1 x verbal agency, initiated by the third person singular; speech act "question", speech act manner "neutral". 1 x verbal agency, initiated by the first person singular, with the third person singular as experiencer; speech act "other", speech act manner "neutral".

Cronbach's α for the agreement on the number of VA identified by the four raters was .91. For VE, the inter-rater agreement was Cronbach's α = .79.

The prevalence of auditory VA and experiences differed significantly across the four physiological states of waking, sleep onset, non-REM, and REM sleep (VA: $F(3, 562) = 16$, $p < .001$, $\eta^2 = .079$; VE: $F(3, 562) = 21.05$, $p < .001$, $\eta^2 = .102$). For VA, post hoc analyses identified significant differences between waking ($M = 0.6$, $SD = 0.93$) and sleep onset ($M = 0.11$, $SD = 0.35$; $p < .001$), waking and REM ($M = 1.04$, $SD = 1.7$; $p = .043$), sleep onset and non-REM ($M = 0.54$, $SD = 1.24$; $p = .002$), and sleep onset and REM ($p < .001$). For VE, post hoc analyses identified significant differences between waking ($M = 0.41$, $SD = 0.61$) and sleep onset ($M = 0.07$, $SD = 0.25$; $p < .001$), waking and REM ($M = 0.86$, $SD = 1.29$; $p = .001$), sleep onset and non-REM ($M = 0.49$, $SD = 0.96$; $p < .001$), sleep onset and REM ($p < .001$), and non-REM and REM ($p = .04$); see Fig. 1.

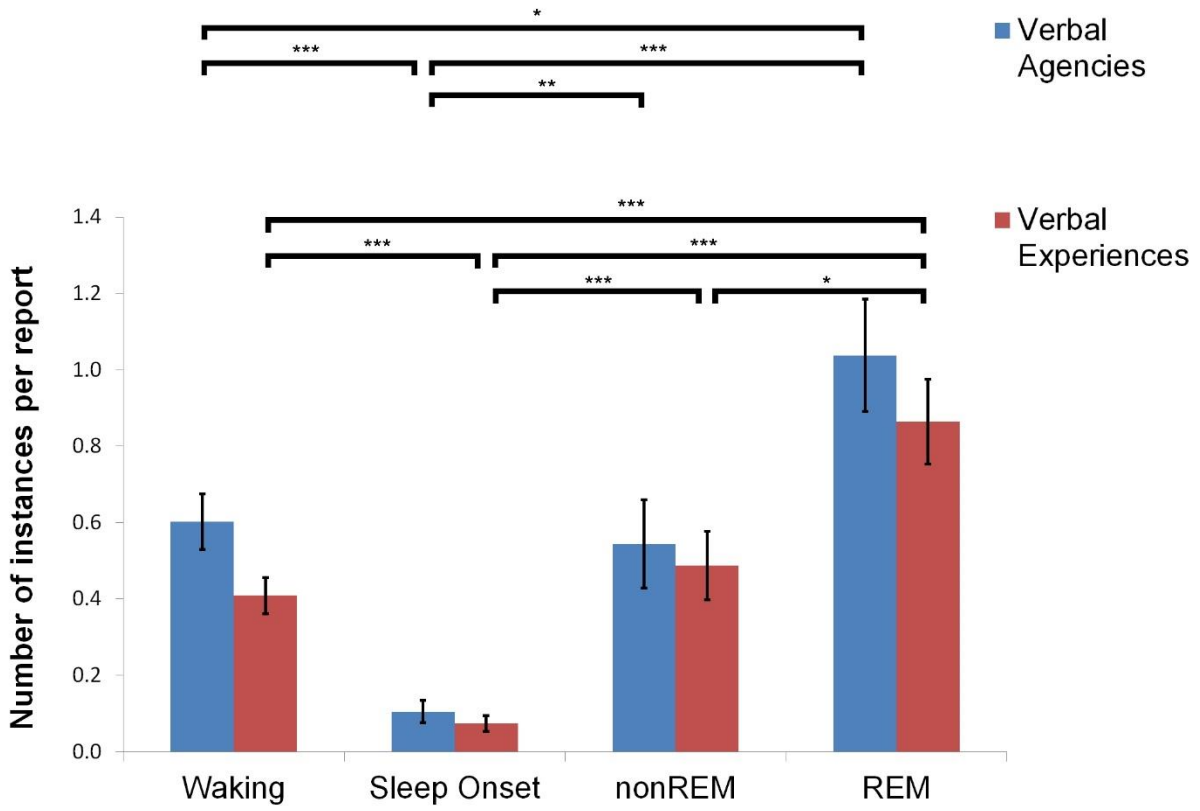

Figure 1. Differences between auditory verbal agency across physiological states (waking, sleep onset, non-REM, REM), and differences between auditory verbal experience across physiological states. Error bars show standard error of the mean. Brackets indicate significant differences in VA and VE. *$p \leq .05$. **$p \leq .01$. ***$p \leq .001$.

Table 2 shows the percentage of reports from waking, sleep onset, REM, and non-REM that showed one or more instances of verbal agency or verbal experience. A report was counted as holding VA or VE instances when at least two raters agreed on at least one occurrence.

Table 2: Percentage of reports from waking, sleep onset, REM and non-REM sleep that showed one or more instances of verbal agency or verbal experience.

	Waking	Sleep Onset	Non-REM	REM
Verbal Agency	35.4 %	7.3 %	29.6 %,	47.0 %
Verbal Experience	39.6 %	9.3 %	35.7 %	53.0 %

3.1 Subdimensions of verbal agency and verbal experience

A multivariate analysis of covariance that corrected for the overall number of VAs per state indicated an effect of the independent variable *state* on the dependent variables, the subdimensions of VA (Wilk's $\lambda = .8$, $F(75, 1597.197) = 1.63$, $p = .001$, partial $\eta^2 = .071$). For VE there was no significant effect (Wilk's $\lambda = .88$, $F(69, 1604.5) = 1.09$, $p = .30$).

Univariate analyses of covariance (ancova) identified the relations between state and the subdimension of VA while correcting for the overall differences in the number of VA between the states. The significant relations are reported in Table 3.

Table 3: Differences in subdimensions of auditory verbal agency across the physiological states (waking, sleep onset, non-REM, REM). The probability values (p) and effect sizes (partial η^2) of one-way ANCOVAs are reported. Below, p values of post hoc pairwise comparisons of Fisher's *least significant difference test are given*. State 1 – State 2 indicates the size and direction of the significant difference between two states.

	State 1	State 2	State 1 - State 2	p	Partial η^2
Verbal agent					
Reporting subject in his/her imagination				.005	.023
	waking	non-REM	.09	.007	
	waking	REM	.11	.001	
Specified person				.005	.023
	waking	sleep onset	-.08	.021	
	waking	non-REM	-.12	.003	
	waking	REM	-.11	.003	
Unspecified person				.004	.023
	waking	non-REM	-.04	.014	
	waking	REM	-.06	.001	
Disembodied voice				n.s.	
Non-human character				n.s.	
Agent perspective					
1st person				.027	.016
	waking	non-REM	.08	.029	
	waking	REM	.09	.005	
3rd person				.000	.035
	waking	sleep onset	-.09	.020	

	waking	non-REM	-.15	.000	
	waking	REM	-15	.000	
Speech act adequacy					
adequate				n.s.	
Possibly random				.021	.017
	waking	sleep onset	-.04	.033	
	waking	non-REM	-.05	.005	
	waking	REM	-.04	.026	
Speech act quality					
Acoustically comprehensible				n.s.	
Psychological neologism				n.s.	
Acoustically incomprehensible				.009	.021
	waking	sleep onset	-.02	.036	
	waking	REM	-.03	.001	
Speech act manner					
Nice				n.s.	
Dominant				.003	.024
	waking	non-REM	-.08	.000	
	sleep onset	non-REM	-.05	.026	
	non-REM	REM	.04	.050	
Nasty				.024	.017
	waking	REM	-.04	.006	
	sleep onset	REM	-.03	.022	
	non-REM	REM	-.04	.013	
Scary				n.s.	
Neutral				n.s.	
Experiencer					
Reporting subject/ group including reporting subject				.040	.016
	waking	non-REM	-.08	.007	
	sleep onset	non-REM	-.07	.029	
	non-REM	REM	.07	.031	
Other character /excluding reporting subject				n.s.	
Unspecified/unclear				.001	.031
	waking	REM	-.08	.000	
	sleep onset	REM	-.049	.021	
	non-REM	REM	-.07	.002	
Experiencer reply					
Reporting subject/ group including reporting subject replies				.048	.015
	sleep onset	REM	.05	.048	
	non-REM	REM	.08	.008	
Reporting subject does not reply				n.s.	
Other imaginative characters reply				.016	.018
	waking	sleep onset	-.05	.010	
	waking	non-REM	-.05	.004	

4 Discussion

This study set out to investigate auditory verbal experiences and agencies across states of consciousness, aiming to compare the relative numbers of VE and VA in waking, sleep onset, REM sleep, and non-REM sleep. VE and VA were measured as linguistic instances of auditory verbal agency and experience of the participants, or (indirectly) of imaginative characters and disembodied voices in the participants' imagination, as identifiable in mentation reports.

4.1 Practicability and reliability

The raters show excellent agreement in identifying the numbers of VA in the reports. Inter-rater agreement was lower for VE. The inter-rater reliability achieved by the raters in our study, without intense training or a psycholinguistic background, indicates that our tool of quantitative linguistic agency and experience analysis is an easy-to-apply, reliable tool to measure VE and VA as they are expressed in the language of mentation reports.

4.2 Quantity of verbal experience and agency between physiological states

The quantity of VE and VA is a function of the physiologically distinct state of consciousness in which they are conceived. Our comparison of reports from four physiologically distinct states of consciousness suggests that sleep onset hallucinations, traditionally at the focus of scientific attention on AVHs and related phenomena, showed the lowest number of VE and VA in comparison to the other three states. There are no differences in VE and VA between waking and non-REM. Rapid eye movement sleep exhibits a significantly higher degree of VE and VA than non-REM sleep, sleep-onset hallucinations, and waking mentation. Together with previous observations that REM sleep exhibits the highest level of bizarre mentation content (Mamelak & Hobson, 1989) as well as simulated (imaginative) motor movements (Speth et al., 2013,), this finding preserves the "undisturbed […] association of REM sleep with a unique class of mental

fantasy" (Foulkes, Spear, & Symonds, 1966, p. 280). Note that, although the criterion used was quite liberal, virtually no references to disembodied voices were found in our analysis of over 500 reports from healthy participants.

Previous research estimates that auditory experiences occur in more than half of all nightly dreams (McCarley & Hoffmann, 1981; Zadra et al., 1998). The present results indicate that about half of all REM sleep reports show at least one instance of auditory *verbal* experience or agency in the form of VA (47%) or VE (53%). Non-REM sleep reports exhibit VA in 29.6%, and VE in 35.7% of all cases. In the light of the current results from a large database of reports from physiology-monitored states of consciousness, it can be assumed that earlier estimates of auditory experiences were made based on reports from specifically REM sleep, and that these auditory experiences were auditory *verbal* experiences. This study adds the insight that the number of auditory verbal experiences in non-REM is much lower. These results are consistent with earlier findings on agency in sleep onset and REM, in that REM sleep exhibits higher rates of both motor agency (Speth et al., 2013) and verbal agency than sleep onset. Note that the present results indicate that VE and VA occur most frequently in REM sleep. REM sleep dreaming has been compared with acute phases of psychosis/schizophrenia (Hobson, 1997, 2004, 2009). Our findings thus appear to support the assumption that AVHs, and AVHs as they occur in states of psychosis, are indeed strongly related to inner speech (Jones & Fernyhough, 2007b). The results are further consistent with neurophysiological findings on ACC activation during AVHs in schizophrenia and during REM sleep (Buchsbaum et al., 2001; Lennox et al., 1999; Muzur et al., 2002; Shergill et al., 2000; Silbersweig et al., 1995). In that sense, VE and VA could be added as another variable to the psychophysiological activation-synthesis hypotheses of dreaming (Hobson & McCarley, 1977).

4.3 Quality of verbal experience and agency between physiological states

Not only is the *quantity*, the absolute number of VA and VE instances, a function of physiological states, but so also is their *quality*. The subdimensions of VA analysis allow us to test differences in the qualitative, namely linguistic-pragmatic patterns, of VE and

VA. Corrected for the primary effect that there are substantial differences in the number of VE and VA across the physiological states, VE and VA differ in their pragmatic form between states.

4.3.1 Grammatical perspective

In waking, the reporting subject takes on the role of verbal agent more often than in REM and non-REM, as represented by instances of grammatical agency in the respective reports. The verbal agent is more often a specified or unspecified person in REM and non-REM. This is consistent with our result that the agent perspective is less often the grammatical first person in REM and non-REM than in waking, and more often the third person in sleep onset, non-REM, and REM. These two complimentary scales of VA thus both indicate a shift in perspective on auditory verbal events between states. This study thereby expands previous findings that identify *dissociation*, namely experiencing mentation from a third-person perspective, as a factor that distinguishes between reports of lucid and non-lucid dreams (Voss, Schermelleh-Engel, Windt, Frenzel, & Hobson, 2013). This study investigated shifts in perspective, as a parameter of dissociation, on a larger scale, and using reports from physiologically controlled states of consciousness. This distinction further points toward a shift from inner speech as VA (perceived from a first-person point of view) in waking toward "hearing voices" (the phenomenon of auditory hallucinations uttered by an imaginary third person or disembodied voice, and perceived from a third-person point of view) in sleep. In a comparison between waking mentation reports from healthy participants versus those diagnosed with schizophrenia, this shift in perspective can thus be expected to mark an increase in what may be defined as AVHs in comparison to inner speech experienced by the participant as originating from his or her first-person perspective.

4.3.2 Speech act adequacy and quality

The adequacy of the speech act in relation to the described imaginative event and conversational situation was judged as less reduced in waking reports than in reports of all other states. Furthermore, the quality of the speech act was judged as more incomprehensible in sleep onset and REM sleep than in waking. These findings fit in with those of previous studies on the overall construct of bizarreness, which has repeatedly

been found to be more prevalent in sleep than in waking mentation (Hobson, 2009; Sutton, Rittenhouse, Pace-Schott, Stickgold, & Hobson, 1994; Williams, Merritt, Rittenhouse, & Hobson, 1992). The reduction in speech act adequacy and quality is likely to result from the prefrontal inactivation during REM. Future studies on bizarreness in states of consciousness may thus benefit from the tools presented in this study, especially as the tools may prove more workable than earlier formal analysis of mentation reports.

4.3.3 Speech act manner

The manner of the speech act was assessed as more dominant for non-REM than for all other states. This adds to previously established characteristics of non-REM sleep, such as the thought-like quality of non-REM sleep mentation (Foulkes, 1967).

In REM sleep, the manner of the speech acts was judged as "nastier" than in all other states. This characteristic of the manner of VE and VA in REM sleep fits in with the findings on negative social interactions simulated in REM sleep, as reported by McNamara, McLaren, Smith, Brown, and Stickgold (2005).

4.3.4 Communicative situation

The reporting person, or a group which includes the reporting person, is more often the recipient of simulated speech uttered by his or her imaginary characters in non-REM sleep than in all other states. The finding that the reporting subject tends to be the *experiencer* rather than the producer of simulated speech in non-REM is consistent with Foulkes' (1967) characterization of non-REM consciousness as passive, thought-like mentation.

In REM sleep, the recipient of simulated speech acts is more often unspecified than in all other states. The reporting subject, or a group including the reporting subject, also replies less often to simulated speech acts in REM sleep than in sleep onset and in non-REM sleep. In that sense, the present findings allow us to add another characteristic to the bizarreness scale for dreams and fantasies, which to date defines bizarreness through discontinuity, incongruity or uncertainty of place, action, characters, objects, time, emotions, or feelings (Williams et al., 1992), and which has been used to show that levels

of bizarreness are highest in REM sleep (Hobson, 2009). It could thus be argued that the *incongruity or uncertainty of (simulated) speech production and reception* be added to future bizarreness scales.

4.4 Limitations

Our tool of analysis is deduced from established linguistic theories, has recently been validated in a modified version (Speth et al., 2013,), and was found easy to apply by the raters. However, this study lacks information on the explicit opinion of the participants on whose mentation reports quantitative linguistic third-person analysis was conducted. A mixed-methods design, comprising both report collection and subsequent questionnaires, would allow for an immediate epistemological assessment of the discrepancies between explicit and implicit introspective knowledge. This study also lacks information on moderating factors such as substance abuse etc., which could influence quantity and quality of VE and VA as potential markers of AVHs and inner speech. It has to be said, however, that the Nightcap database has been cross-validated in a number of physiological as well as phenomenological studies (e.g., Atienza, Cantero, Stickgold, & Hobson, 2004; Cantero et al., 2002; Fosse et al., 2001). It further has to be noted that a stricter definition of AVHs would render results more comparable among studies, albeit it seems that such a definition can only progress along with our research and the tools of analysis.

4.5 Implicit measurements of implicit introspective knowledge on AVHs and inner speech

While Jones et al. (2010) chose questionnaires for their investigation of AVHs, the current study uses the method of quantitative linguistic report analysis to approach VE and VA as potential indicators of AVHs. We argue that *questionnaires on mental events* and *report analyses* measure two different constructs, namely our *explicit opinion* versus our *implicit knowledge on mental events*.

In their online questionnaires, Jones et al. (2010) asked for what we must consider as the sleep onset equivalent of participants' "general *opinions* about dreaming, reached independently of individual instances of dream recall" (Windt, 2013, p. 7). Our study, on

the other hand, relies on our participants' "knowing [of] the phenomenology of dreaming, where one refers to the knowledge of particular dreams, as they are remembered and reported upon awakening" (Windt, 2013, p. 7), or toward the end of other physiological states of consciousness. Windt (2013) warns of an equivocation of the two methods, considering it a crucial mistake that could explain much of the philosophical skepticism of the reliability of introspective insight regarding specifically dream reports (Schwitzgebel, 2011). Windt perceives the method of immediate collection of mentation reports under "*ideal* reporting conditions" as more reliable than questionnaires that ask for participants' explicit opinion on aspects of dream phenomenology (Windt, 2013, p. 8; emphasis preserved). She remarks that Schwitzgebel's (2011) observations on (in that case) the changes in reported dream color, namely "the change from experience reports of predominately black-and-white to predominately colored dreaming in the 1960s," may simply be explained by "a shift from questionnaire studies to studies relying on dream reports following REM sleep awakenings." Our study seeks to approach the ideal reporting conditions demanded by Windt (2013) in so far as we use reports that were collected under experimental conditions.

The differences in the trustworthiness of introspective insight (conceived as general opinions expressed in standardized questionnaires, versus via third-person analyses of mentation reports conceived immediately after a particular period of time) may, however, not depend on the circumstances of recall or reporting alone. We may have to attribute a great part of the diverging outcomes of questionnaire-based versus report-based consciousness studies to the *different methods of analysis* for which the two forms of data collection protocols allow. The trustworthiness of participants' *implicit knowledge* on mental events, quantified through *implicit measurements* of free mentation reports in the form of third-person linguistic analysis, may differ greatly from assessments of participants' *explicit introspective knowledge*, as displayed in their answers to standardized phenomenology questionnaires. It will have to be discussed if the two methods should be considered comparable in the first place. Our implicit introspective knowledge may differ rather dramatically from our explicit introspective knowledge, especially when it comes to sleep onset mentation, recall of which we must expect to be generally poor. We can assume that a phenomenological questionnaire such as the one of Jones et al. (2010) on AVHs in sleep onset captures participants' explicit opinions on

exceptional and therefore memorable sleep onset AVHs that have occurred over the participants' lifetime. Our database, albeit large, is limited to a number of average first-person reports *on states of consciousness in general*. As the report collection procedure allowed for forced awakenings, our study should thereby have yielded information on participants' recall of average sleep onset VE and VA as functions of spontaneous brain activity over the regular sleep waking cycle of humans.

It is noted that the pragmatics and neurophysiological correlates of the internal auditory verbal perceptions of imaginative third-person utterances measured in the two studies may differ as a result of the different experimental methods. Participants may thus have reported memorable VA (originated by imaginary characters or disembodied voices) that differed from everyday VA and VE (originated and perceived "directly" by the subject) with regard to the perceived intensity, the attributed reliability and truth value of the hallucinatory experience, and the authority of the voice, as well as the perceived locus of the voice ("inside my head" versus "in reality").

If psychopathological AVHs are indeed such forms of inner speech that are not recognized as self-produced (Brunelin et al., 2006; Jones & Fernyhough, 2007a,b), then one way to analyze in how far inner speech and "hearing voices" are connected would be to use linguistic tools to compare mentation reports from states of spontaneous brain activity collected from healthy versus clinical populations. Shifts from simulated first-person utterances to those of simulated second and third persons could indicate that inner speech is no longer recognized as self-produced. It is further suggested that healthy versus pathological AVHs may differ with regard to their *verbal* versus *preverbal status* in the process of speech production (Harley, 2014) and near-simultaneous speech processing, as it must occur in the particular case of participants processing verbal utterances by imaginative third persons as psychological extensions of the reporting subject itself.

5 Conclusion

We conclude that the quantity and quality of auditory verbal experiences and agenices in healthy participants are functions of the distinct physiology of states of consciousness.

The relative high quantity of VE and VA in REM sleep in comparison to waking, sleep-onset, and non-REM sleep could be associated with its typically high activation of the ACC, while the inactivation of the DLPFC in REM sleep ties in with the changes in qualitative-pragmatic characteristics of VE and VA.

This study indicates that the objective, implicit third-person analysis of first-person mentation reports obtained under ideal reporting conditions (Windt, 2013) yields reliable information the spectrum of VE and VA as candidate markers for AVHs and inner speech. In spite of the significant differences found regarding quantity and quality of VE and VA across states of consciousness however, it has to be emphasized that reports from all four investigated states exhibited linguistic references to both. This observation should be seen as indicative of auditory verbal experiences and agencies as a universal characteristic of human consciousness. Humans seem to simulate verbal utterances and verbal perceptions across states of consciousness: In our heads, we talk to ourselves, to non-present or imaginary recipients, and we engage in auditory verbal simulations of perceiving verbal utterances, which may be replays or modifications of former real-life speech, or phonetic and semantic rehearsals for future conversations.

While this study aimed to investigate VE and VA across normal states of consciousness conceived by healthy participants as opposed to those displaying symptoms of schizophrenia (World Health Organization, 1992), a future study should compare this healthy baseline against reports conceived by patients with acute schizophrenia across states of consciousness—which will present a bottom-up process of helping to find a tighter definition especially of quantity and quality of AVHs and inner speech in relation to their clinical implications: For some time now, hallucinations have generally been dismissed as error or disturbance, as an epiphenomenon of cognitive processes. We have only now begun to determine the form and frequency of AVHs across states of consciousness along with their inherent cognitive functions. We need these insights if we want to explore the connection between AVHs, inner speech, and other cognitive processes—including the role they play in connection with different psychopathological mechanisms such as in schizophrenia. We may be able to lay the groundwork for better clinical diagnoses and new forms of treatment.

Future research may allow for a finer investigation of AVHs and their connection to inner speech not only with respect to specific psychopathologies, but in terms of their cognitive forms and functions, such as retrospective and prospective memory, planning processes, linguistic capacities and psychological mechanisms. At the same time, we will have to determine the precise physiological markers of VE and VA across states of consciousness, especially for sleep onset and non-REM sleep. Such psychophysiological integration (Hobson, 2009) will lead to a better understanding of human consciousness, and subsequently improve clinical diagnoses and treatments of different language disorders and psychopathologies. In the sense of a multiphenomenological approach to consciousness (Dennett, 2003), we suggest that if conducted with mixed-method designs, such research could also yield more insight on discrepancies between explicit and implicit introspective knowledge on one's own mental events, and its adequate measures.

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